

Article

Global Challenges of Digital Transformation of Markets: Collaboration and Digital Assets

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Abstract: Cyber-physical system (CPS) and digital twin (DT) technologies are the key enablers of smart manufacturing. The main idea of CPS is to build bi-directional interaction channels between the physical and cyber worlds. The research gap is ontological consideration of the concept of the digital object (DO) as a representation of a physical object (PO) in the digital space/world. The objective of this study is an ontological analysis of the digital object (DO). This object is fairly well-understood from a technical point of view; although there are many options for its definition, its basic composition and functionality are defined clearly, but currently in the economic science DO has not yet been enough considered. The DO, which first appeared as a digital twin has not been properly explored by economic science. Authors attempt to determine whether all the properties and characteristics of the DO are described by modern economic language or whether there is a need to introduce new concepts and categories to describe such objects. The ontological analysis of the DO within the existing conceptual framework of economic science is presented. The result of the research is comprehensive study of DO which allows the consideration of the additional benefits that economic actors can gain from using the DO. We propose to analyze the DO in terms of such economic categories as goods; innovation process; the system of division of labor; the role of market participants in the creation and use of the DO; intellectual property; etc.

Keywords: digital economy; digital assets; digital object; digital twin; economic categories



Citation: Yadykin, V.; Barykin, S.; Badenko, V.; Bolshakov, N.; de la Poza, E.; Fedotov, A. Global Challenges of Digital Transformation of Markets: Collaboration and Digital Assets. *Sustainability* **2021**, *13*, 10619. <https://doi.org/10.3390/su131910619>

Academic Editor: Alexey Mikhaylov

Received: 19 July 2021

Accepted: 22 September 2021

Published: 24 September 2021

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1. Introduction

Industry 4.0, known as the fourth industrial revolution, has been related to the digitalization of production, primarily in the real sector of the economy, but now is associated with mass introduction of cyber-physical systems into the production process. Industry 4.0 leads to the emergence of the so-called digital factories of the future. The most recent and creative advancements of Industry 4.0 impact on product and production channels. The organizations can adopt the latest technologies that direct them to achieve proficiency and profitability, as Industry 4.0 allows organizations to create innovative and quality product. This new industrial paradigm brings together the digital and physical worlds through the cyber-physical systems (CPS) enhanced by Internet of Things and it is expected that this novel approach has consequences on industry, markets, and economy, improving production processes and increase of productivity, affecting the whole product lifecycle, creating new business models, changing the work environment and restructuring the labor market [1,2]. The transition to Industry 4.0 is crucial for manufacturing firms to sustain competitive advantage and seize new opportunities.

Mentioning the «Digital Transformation» we refer to the transition to the Industry 4.0. as a part of the Digital Transformation process. Industry 4.0 could be considered as a transformation from machine dominant manufacturing to digital manufacturing [3].

Cyber-physical system (CPS) and digital twin (DT) technologies are the key enablers of smart manufacturing. The main idea of CPS is to build bi-directional interaction channels between the physical and cyber worlds, and establish the Internet of Things (IoT) in the physical world to connect various sensors, actuators, and controllers with products and equipment for real-time data perception, transmission, processing, feedback, and service [4,5].

One of the key concepts within Industry 4.0 is the so-called smart factory. The smart factory depicts a future state of a fully digitalized manufacturing system, mainly operating without human force by generating, transferring, receiving, and processing the necessary data to conduct all required tasks for producing specific kinds of goods. Again, it is coherent that the smart factory concept must be approached with altering focal points and therefore cannot be covered by one single research stream [6].

The approach we propose to studying the digital object (DO) and, accordingly, the generated by DO asset (considered in this article) differs from the existing approaches prevailing in the IT sector. The DO is generally understood in literature as a system of information communications between the participants of the used DO. At the same time, the DO in production is understood as a replica of a physical object (PO) into the digital space/world, reflecting all DO properties. The DO makes it possible to study the behavior of a PO in digital space under various operating conditions, which is often cumbersome and expensive to test and implementing in the physical world. Predictive analytics is understood in information technology (IT) as possible scenarios for the behavior of people rather than objects.

Thus, ontological consideration of the concept of DO as a representation of a PO in the digital space/world is an urgent task, the solution of which is presented in the article. A concept of DO has appeared relatively recently to describe the production activities of enterprises in connection with the digital twin technology. The focus in this study is the additional value that participants of industrial economic activities can create by using the DO.

2. Literature Review

The transition to digital manufacturing technologies of Industry 4.0 is critical for industrial enterprises to be able to retain a competitive edge and exploit new opportunities. The implementation of the Internet of Things (IoT) and the Information and Communication Technologies (ICT) allows developing the concept of Smart Farming management tasks not only on location but also on data, providing the farmer with added value in the form of better decision-making or more efficient exploitation operations [7]. Such terms as “Smart Farming”, “Digital Farming”, “Internet of Farming”, and “Agriculture 4.0” (in analogy to Industry 4.0) are used due to the changes in social, environmental, as well as economic issues [8].

The main sector/industry that could benefit more from Industry 4.0 Industries with a high level of product variants could be both the automotive [9] and food-and- beverage industries [10]. The most recent technologies (IoT and Big Data) and data management are involved in the evolution of Precision Agriculture (PA) toward forms of farms management [11,12].

Most research has focused on the technological aspects of Industry 4.0 in the form of product and process innovation [13]. With the development of new generation information and communication technologies, the production mode has been shifting from mass production to mass individualization, and the corresponding production system has been evolving from automated to autonomous. Smart manufacturing, as a concrete embodiment of mass individualization, has been proposed in many national strategies.

The first industrial revolution took place owing to the steam engine, dramatically increasing labor productivity in the 19th century, the second one was marked by mass conveyor belt production at the beginning of the 20th century, the third revolution can be attributed to the automation of the early 1970s, and, accordingly, the fourth industrial revolution means the emergence of a new labor distribution system, based on using digital and information technologies industry.

Industry 4.0 has been proposed as a new industrial maturity stage based on the connectivity provided by the industrial Internet of Things (IoT) and the use of several digital technologies such as cloud computing, big data, and artificial intelligence. These technologies allow the connection of objects such as products and equipment to form CPS and to enable new technology applications such as additive manufacturing, adaptive robotics, and flexible machines [14].

Despite the opportunities originating from digitalization at each stage of the production and service systems, the management side of Industry 4.0 has not yet been studied in depth and its definition remains ambiguous, even if it has already been stated that Industry 4.0 must be considered as the result of a purposely formulated strategy implemented over time. Although its manufacturing basis is focused on new technologies, the next industrial revolution, Industry 4.0, already lead to both important changes in societies and the adaptation to changing environments [15].

Additionally, the latest technologies help organizations in waste reduction and resource efficiency. The eco-based technologies facilitate to gain environmentally sustainable manufacturing and boost sales with huge cost savings. In Industry 4.0, organizations can go for speedy decision-making with the real-time data as it enables control of production arrangement, competency utilization, and energy savings. Because of their specific nature, involving interdependency and value co-creation, Industry 4.0 innovation ecosystems have emerged as a more suitable configuration for technology development and provision instead of the linear supply chain approach. As previously demonstrated by Rong et al. [16], supply chains become very intricate in the Industry 4.0 context, with many players and complex interactions [17,18]. The ecosystem approach is more suitable to analyze this case. Industry 4.0 innovation ecosystems are especially important for small and medium-sized enterprises (SMEs) due to their limited financial resources to acquire the interdisciplinary knowledge and capabilities required to develop complex solutions independently [19]. Affected by industrial trends and the progressing technological development, manufacturing enterprises are confronted with a growing complexity within the factory. Quick market changes and a strong individualization of products create the necessity for high agility of the production management and the factory structure [20]. The Industry 4.0 concepts are proposed to enable companies to have flexible manufacturing processes and to analyze large amounts of data in real time, improving strategic and operational decision-making. This new industrial stage has been possible due to the use of information and communication technologies in industrial environments [21]. With the deep integration of intelligent technologies in the manufacturing industry, there has been a digital transformation that has changed the traditional production and operations management methods and offers the potential for the improvement of product development, production efficiency, and customer service. Moreover, these advanced technologies can enable the efficient allocation of resources and therefore unlock the full potential of environmental sustainability [22]. The work [23] analyzes the relation between the information provided by companies in the technology sector about their socio-environmental actions, their economic results, their size, the value of their brands, their score in the rankings of CSR, and its credit ratings. The study [24] empirically evaluates the degree of similarity in international brand valuation rankings that apply to the IT sector. However, most of the studies on digital transformation of traditional manufacturing companies focus on technological aspects in the form of innovations in products and processes, while economic and organizational aspects are overlooked.

At the same time, economists carefully study IT giants (Facebook, Amazon, Google, etc.), whose shares are traded on the world's leading stock exchanges [22,23]. The financial system is currently undergoing a revolution driven by e-Finance, digital convergence, the emergence of new market participants, and government-encouraged competition. New market entrants such as Apple, Alibaba, Facebook, and Google come from industries such as retail, social media, and telecommunications, and therefore do not fit into traditional financial institutional structures [25]. Platforms provide users with various social and technical boundary resources, such as application programming interfaces (APIs) that provide access to data, software development kits and various templates that dramatically lower the cost of use. To be successful, a platform must attract and connect a combination of users, customers, service or product providers, advertisers and other actors, who collectively form the platform's ecosystem [26]. IT companies such as IBM, Microsoft, HP, Oracle, Xerox, have digital technologies that have no physical prototype in the real world [27–29]. At the same time, many companies of the real sector of the economy have traditional physical objects (POs) such as buildings, machinery, equipment as their main assets. Modern technologies for creating new POs are based on digital technologies. For example, the automotive industry has completely switched to the creation of the DO in the recent years, shortening the period for development and implementation of a new car from 5–7 years to several months. The main technologies that allowed industries to change their systems of division of labor are the digital twin technologies. The term as accepted today embraces more broadly the technological, organizational, economical, and societal changes driven by enhanced digitalization of manufacturing industry [30]. Digital Twin, acting as a mirror of the real world, provides a means of simulating, predicting, and optimizing physical manufacturing systems and processes [31–33]. Using the digital twin, together with intelligent algorithms, organizations can achieve data-driven operation monitoring and optimization, develop innovative product and services, and diversify value creation, business models and building information modelling (BIM) [34–36]. The use of BIM concentrates on preplanning, design, construction, and integrated project delivery of buildings and infrastructure, but since recently, research focus shifted from earlier life cycle (LC) stages to maintenance, refurbishment, deconstruction, and end-of-life considerations especially of complex structures [37,38]. BIM is a set of technologies, processes, and policies enabling all multiple stakeholders to collaboratively design, construct, and operate a building or a facility in a virtual space. BIM is modeled using dedicated software tools, and consists of parametric objects that hold information regarding the geometry and other attributes (e.g., functional, semantic and topographic information) of building components [39,40]. The emergence of digital technologies in turn lead to the emergence of new entities, DOs, which represent POs with a high degree of accuracy, and, as a consequence, to the emergence of the concept of the digital asset in the real sector of the economy [41].

3. Research and Methodology

The analysis was carried out by ontological methods to identify the fundamental features of DOs in order to understand the structure, patterns of development, and interaction of these entities, associated with the production process. To consider this extensive topic, we propose to apply a general methodological approach to solving the problem of systematizing the conceptual framework (Figure 1).

The following tasks from the standpoint of economic science have been set: Determining the properties of a DO aimed at meeting the needs; exploring how collaboration between various economic actors affects the process of creating a DO; discovering the additional benefits that economic actors can gain from using the DO.

The proposed method of analysis takes into account that from a technical standpoint, DOs are fairly well understood, although there are many definitions for the concept. The basic composition of the DO, its functions and capabilities are well described in technical sciences. However, the DO has received relatively little attention in economics; there is as yet no clear economic terminology in the field of the digital economy related to production.

The PO, which is created as a result of production, has been comprehensively described from an economic standpoint. Buildings, machinery, equipment, products are the concepts well understood in economics. From an economic standpoint, the DO is primarily regarded as a reflection of the PO in the virtual digital world, developing further as an independent addition to the PO, forming a single inseparable entity with it.

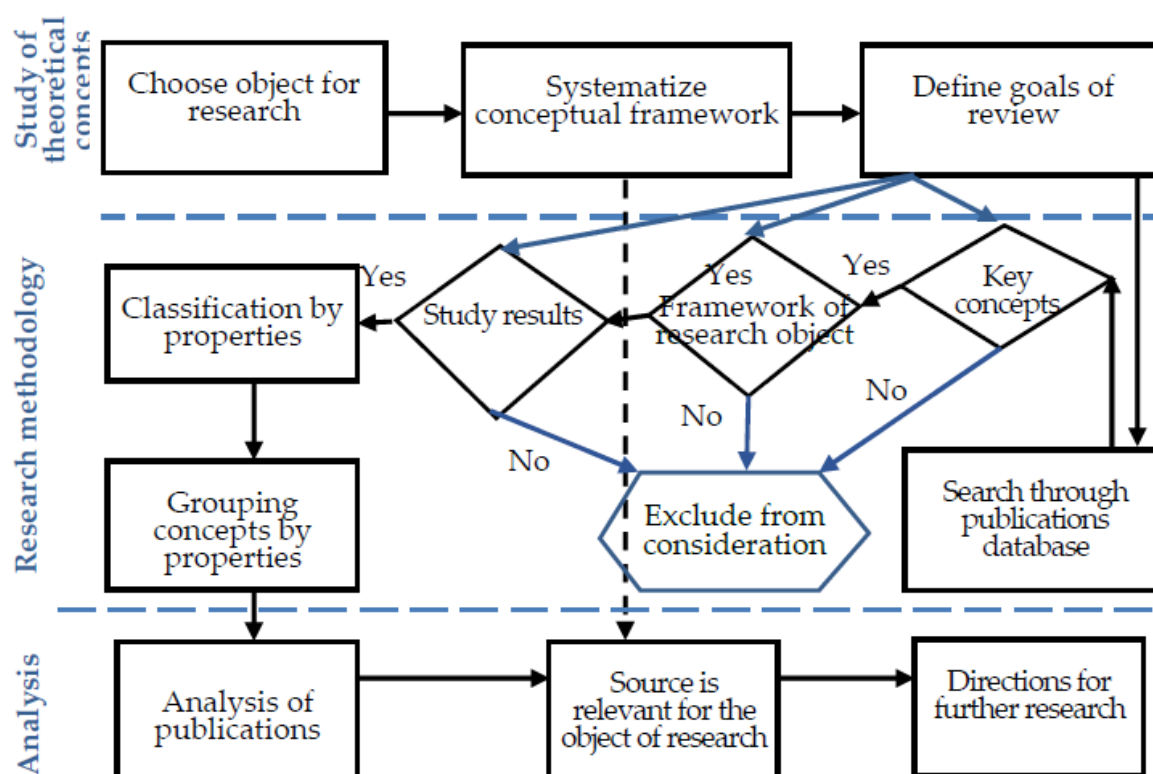


Figure 1. Logic of research.

Both the PO and the DO should be considered as a single whole, where the DO is a reflection of the PO in the digital world. Traditional Chinese medicine represents this unity in the form of yin-yang. The digital twin links the physical and virtual environments. The PO continuously transmits operational and maintenance data to update the virtual model in the DO. Thus, the digital twin is an accurate representation of a PO in real time, regardless of its changes. In the following, we will use the terms DO and digital twin synonymously.

We have applied a method for determining the composition, characteristics, and relationships of the DO from the standpoint of the existing conceptual framework of economic science. Our objective was to understand whether all properties and characteristics of the DO are described by the modern economic language, and whether new concepts and categories have to be introduced to describe them. For this reason, the method considers the DO in terms of such economic categories as product, innovative process, division of labor, role of market participants in creating and using the DO, intellectual property, etc.

4. Results

Let us consider the main four stages in which the concept of DO evolved. For some time, the DO was used independently of the PO, rather, as a model necessary to develop and create the PO. As quality and accuracy of the models grew, it turned out that studying and testing DOs was considerably cheaper and faster (as examples of the automotive industry replacing full-scale tests with virtual ones indicate). This way, the DO began to complement and enrich the PO. An example is the development of heavy-duty turbines

by Siemens. Siemens and Grundfos have signed a digital partnership framework for strategic cooperation to tackle global water challenges and save energy. The new long-term co-development digital partnership focuses on water and wastewater applications, industrial automation, and building technology [42]. Furthermore, digital technologies made it possible to find critical points in the object; the so-called smart digital twins that can be constantly trained appeared [43]. This made it possible to model not only the object and its operating modes but also its entire lifecycle with a trainable smart DO constantly accompanying it. Thus, a new virtual object containing data on the PO appeared. The DO is inextricably linked with the PO; using DO allows significantly (in some cases by an order of magnitude) to shorten the time for decision-making, and greatly reduce the risks, both technical and financial.

It can be argued that the DO adds value to the PO throughout the entire life cycle of a process, system, or organization. DOs (DTs) start creating value at the stage of design. The relationship between capital expenditures and the phases of operating expenditures allows to assess this value created.

4.1. Properties of DO as a Commodity

According to Lionel Robbins, economics is defined as “the science which studies human behavior as a relationship between ends and scarce means which have alternative uses” [44]. Robbins’ rationale for focusing on the isolated individual could be treated as the starting point for economics [45]. The three basic postulates of the Robbins’ Essay—(1) that individuals can order their preferences, (2) that there exists more than one factor of production, and (3) that there is uncertainty about future scarcities – only needed “to be stated to be recognized as obvious”, and there was no need for controlled experiments to validate them. These basic postulates were not, however, self-contained principles, and subsidiary postulates were required to apply them. Since these subsidiary postulates were not known a priori, Robbins wrote, “before we apply our general theory to the interpretation of the particular situation we must be sure of the facts”. In view of this, economics can be regarded as the science of rational choice made by calculating maximized results provided with minimal funds. At the same time, economic science is dedicated to the issue of consumption, i.e., how people allocate their funds between different types of goods and services, how they make a choice between competing goods and services, how manufacturers inform/manipulate consumers to sell their goods. Thus, the concept of a product is the first of the economic categories to be considered. Economics usually considers three layers of a product. Figure 2 shows a schematic representation for the layers of a product.

Let us consider the DO in terms of a product category. Let us suggest a classical categorization of the concept of three layers of sales questions: the main benefit; the ready product; augmented product (Figure 2).

The following categories can be proposed to describe the DO:

Layer 1 of the DO of the product is the main benefit.

Properties of a DO forming a product designed, aimed at satisfying a need [46–49]:

- Information about all characteristics and parameters of the PO: information completeness;
- Ability to simulate the behavior of an object, its nodes and elements in various conditions, predict changes in the parameters of the processes and characteristics of the PO: predictability;
- Ability to contain all nodes and elements of the object together, considering all hierarchical layers up to each individual element: hierarchical integrity;
- DO represents the PO with a high degree of accuracy;
- Ability to train, integrating all the data obtained during the operation of the object;
- Ability to be easily integrated into higher-level objects.

Layer 2 of the digital twin of the product is the real physical product.

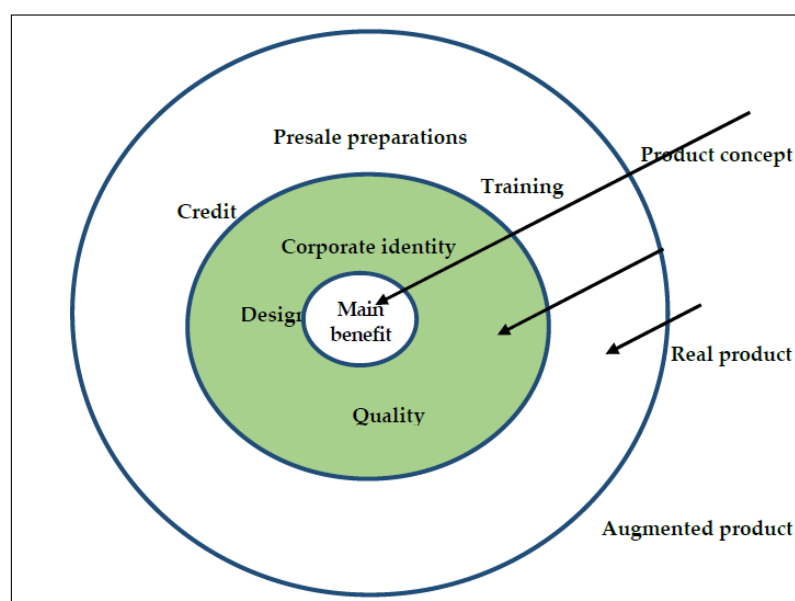


Figure 2. The three layers of sales questions from the standpoint of economic theory and Source: <https://blog.hubspot.com/sales/layers-sales-questions> (accessed on 19 July 2021).

A DO has consumer properties; as the components of the DO, they can also be represented as the information disseminated for advertising purposes [50,51]:

- DO can form the augmented reality (AR) and the virtual reality (VR) environments for visualizing the PO for the purposes of object management, marketing, personnel training, etc.;
- DO allows to predict with high accuracy the costs of maintaining/operating an object throughout the entire lifecycle;
- DO allows to simulate maintenance and repairs of the PO throughout the entire lifecycle;
- DO allows to simulate the process of object management (decision-making) in normal and emergency situations, ensuring safety including in case of emergencies;
- DO allows to create a range of solutions to quickly change the style, design and some consumer characteristics of the object.

Layer 3 of the digital twin of the product: augmented product.

The following characteristics of a DO are related to post-sales services, for example, adding information.

Virtualization has the ability to: Make heterogeneous objects interoperable through the use of semantic descriptions; enable them to acquire, analyze, and interpret information about their context in order to take relevant decision and act upon the virtual objects. Moreover, it enhances the existing functions offered by the IoT, supporting the discovery and mash up of services, promoting the creation of new addressing schemes, improving the objects mobility management efficiency, as well as addressing accounting and authentication issues [52–54]:

- Automated object management based on elements of the Internet of Things (IoT), distributed and remote control of the object;
- Solutions can be scaled quickly;
- Financial and technical transparency of operation process (lending/insurance).

Thus, we can conclude that the DO can be regarded as a product, since it carries a clear economic benefit. In this case, the DO forms a number of new qualities that were not previously available for most POs. This can be compared to the transition to another dimension, from linear to planar and, further, to volumetric. The combination of physical

and digital assets produces new qualitative characteristics that change the concept of the product as a merely PO.

It can be concluded that the divisibility of the DO is manifested in cooperation, in the ability of different economic agents to unite in order to achieve joint benefits. At the same time, the benefit of each participant and the multiplicative benefit are not commensurable. Integrity allows to satisfy all consumer needs at once. This raises the question of the contribution of each participant to the creation of the product. An obvious conclusion is that it is not the investor/customer who becomes the key figure but the integrator of the process who decomposes the consumer qualities of the product into technical requirements, down to the level of subsystems and elements. There is an analogy with the physical product, as the integrator obtains the maximum profit due to satisfying the customer's needs.

While the integrator previously assumed all the risks of integrating a system element into an object during the production of goods, a new entity has now evolved for this function: a digital platform for creating a new product. The main goal of the digital platform is to generate conditions for the most effective integration of individual elements into a single whole.

A system integration method has been developed in industrial production, which in economic language can be called cooperation. This method offers a different outlook on the basic principle of competition. The requirement of cooperation brings to the fore the principle of integral benefit, when a product (or its element) is compared not by its actual properties but by an integral characteristic that ensures the satisfaction of the consumer's needs.

MBSE (Model Based System Engineering) is one of the most common methodologies used in modern systems engineering [55]. As a concept, MBSE has been discussed since the late 1990s, and since 2006 as an initiative of INCOSE40; its modern interpretation was forged at the international conference on MBSE which took place in 2010.

4.2. *Changing the Division of Labor*

Manufacturing is the backbone of almost any economic activity. Manufacturing changes are the most powerful sources of social transformation. Industrial revolutions serve as an example of this. The modern world is created as a result of changes in technology and work organization systems. Digital technologies have a significant impact on the systems of division of labor. It is evident that new factors of production other than land, labor, and capital are evolving.

In traditional manufacturing, the design phase makes up about 10–20% of the total cost of creating a product. The main costs, up to 80–90%, are spent on manufacturing, testing, and fine-tuning the prototype. This proportion is changed with the DT technology, drastically reducing the product launch times. For example, the launch times of new products in the automotive industry are only 3–4 months, since the DTs of products and processes are already created [56]. Conceptually, this is explained by the fact that knowledge always appears with experience, which is born from experiments. Experience in human history has always taken long to accumulate and/or has been expensive to gain. The DO allows to transform experimentation as a necessary function for creating the product from long and expensive to cheap and fast. This is due to computing speed, and the software product embodying the knowledge that took millions of person-years to obtain. Apparently, the DT technology allows to gain new knowledge quickly and cheaply, owing to the ultra-low transaction costs for product development.

All of this points to a change in the distribution of labor in the digital economy. The center of gravity in creating goods, products, and services is transferred to the stage of design/creation. The production process becomes purely technological. All requirements for it and all operations are already established at the design stage. This suggests that the stage of production becomes subordinate to the stage of design. The stage of using a product/service is also modeled at the stage of design. Even though there is potential for

creativity in client relations, all possible scenarios for product consumption are worked out at the design stage. This makes a significant contribution to reversing the roles of participants in the labor distribution system. The manufacturer of the goods/products is increasingly shifting toward providing services using the product replacing the traditional system of selling goods to the market. An example of this is General Electric's concept of transition to the power generation market, with gradual withdrawal from the power equipment supply market. A similar approach is demonstrated by car manufacturers entering into alliances with car-sharing companies (Volkswagen-Audi and Uber). Thus, it can be argued that digital technologies significantly affect the division of labor, replacing the competition of goods with the competition of services and transforming the competition of solutions into cooperation of solutions, generating a new factor of cooperation, and, in fact, industrial production that is the digital platform [48,57–64].

Consider the basic provisions of economics proposed by Adam Smith, monopoly and oligopoly. Today, the unique offer that the company offers is a benefit rather than a problem for a huge number of people in the world. Companies such as Amazon, Walmart, Google, Microsoft, Tesla, and others sometimes determine what will be produced and where and what people will buy, and who will profit from it, often in what amount.

4.3. Digital Platforms

Since the development of a new product based on digital technologies is now becoming central to the division of labor, the task at hand are the measures that need to be taken to ensure this. Given the multidisciplinary nature of the product, it becomes unprofitable for one company to keep an entire staff of specialists from different fields. An additional question concerns the accumulation and preservation of the manufacturer's knowledge base about the product. As a consequence, digital platforms based on the MBSE system appeared on the market. MBSE is one of the most common methodologies used in modern systems engineering. The new business model for creating the product is cooperation/association of knowledge-bearing groups. This association exists only during the time required to create a product or a part of a product. This is a new matrix structure.

In the most general terms, MBSE is engineering based on a single consistent model of the system to be designed, combining all the data and properties about this system. This is a concept for applying formalized modeling to generate the requirements for support, design, analysis, verification, and validation of the system at all phases of its lifecycle.

Analysis of systemic disasters revealed a number of problems related to designing complex multi-component objects, including insufficient communication (especially during transitions between different models), outdated specifications or incomplete product requirements, weak control over the configuration, insufficient quality of testing for errors, and inability to ensure smooth degradation of the system in case of failure.

The MBSE concept is a response to these challenges and is intended for generalizing the knowledge models, improving communication provided by the models; generating a more accurate assessment of the models for their consistency, completeness, and correctness; improving analysis of the consequences of changes in the system; improving methods for overcoming complexity and improving the quality of the system created; improving knowledge extraction and reuse (resulting in shorter cycle times and lower maintenance costs), and minimizing knowledge loss after team members leave [65].

For developing a product that is a DO based on the DT technology, developers go through several scenarios, often obtaining important secondary solutions. Thus, a large number of people/companies are involved in product development. However, the modern legal framework does not take into account the rights for DO. There is no such object in today's legal field, and there are no rights to it; the new division of labor needs a description of this object. This is especially important for describing the roles of the participants cooperating to create the DO. The key factor in creating the DO is the question of who accumulates the entire knowledge base of the product. Today, all leading companies use their digital platforms to both integrate solutions and build a knowledge base that is a

repository of different local problem-solving scenarios. As the example of the automotive industry proves, the capacity for integration is key in creating a new product.

4.4. Consumer as Participant in the Process of Creating the Product

Complex technical objects are always created by those who accumulated experience in technology. This often happens in different climatic conditions, with slightly different raw materials, and significantly different production culture. Moreover, such products are often created by local companies, which have different production cultures. Therefore, the launching and fine-tuning processes take a lot of time and money. At the same time, providers of technology and solutions want to protect their know-how, enshrining it in different operating modes and restrictions. The DO technology allows to consider the entire lifecycle of the object with all the aspects characterizing its creation and operation. DT technologies are a basis for controlling the lifecycle of a product. Thus, the consumer becomes a contributor in creating an object. This approach has engendered a paradigm shift for product manufacturers. Understanding how their products works throughout the entire lifecycle of the DO, and understanding all the costs, the manufacturers of the products become service providers (e.g., General Electric with electric energy, Audi/Volkswagen with car sharing). All of this changes the requirements for the product and its manufacturing, for example, management of the resources of the elements and the whole product. The DO becomes the pivotal object. All parties want to gain access to it. What are the conditions? Who makes which contribution? Where are the limits of each participant's contributions? There is no product without cooperation, so the key to creating a product is the principle of cooperation/collaboration. How should it be implemented? If the consumer is involved in cooperation, where is the competition? It becomes a competition of consumer properties: the consumers decide what they need, creating the products for themselves.

A significant factor today is the customer's participation in creation of the product. While previously the role of the client consisted of forming the consumer qualities of the product, now the digital platform is a tool allowing to model/predict the entire lifecycle of the product, making decisions about the requirements for the product elements, based on the entire lifecycle. Before, the client ordering the product took all of these risks. Including the operating organization in developing the product along with the manufacturer allows to combine all types of knowledge about the product, which were previously dispersed in time and space. All this has a consequence that a new division of labor is emerging, transforming from a linear (sequential) system into a matrix one (where everyone interacts with everyone). This is possible only when the principle of trust is in effect, and this is what the DO provides.

To quote Cicero, *cui bono?* Who benefits from this? It turns out that the DO is becoming beneficial to almost all participants of the labor division system. The DO is based on the principle of transparency, allowing each participant to contribute to the maximum satisfaction of the needs of the buyer/consumer, especially since the latter takes an active part in creating a product/service.

4.5. Autonomous Technologies

Mankind has always tried to facilitate labor-intensive operations, in particular calculations. This is how the abacus, arithmometer, and computer appeared. With the rise of digital technology, it has become possible not only to perform computations but also to choose from a set of possible scenarios. AI algorithms, or, more precisely, intelligent assistants have appeared that can quickly suggest possible options and calculate them. They greatly speed up experimentation at times and orders of magnitude. However, the computer cannot think. Therefore, people should shift toward creativity, developing creative thinking and leaving abilities to experiment for the computers, which earlier only nature has been doing for years, millennia.

Given the opportunity to simulate the entire lifecycle of the product, it is possible to model the system for controlling the object/product. This is the path to autonomous

technologies. The DO allows modeling/forecasting scenarios, which allows automating most of the decisions made by transferring the monitoring function to any location via the Internet of Things. This contributes greatly to developing concepts for factories of the future, when the production and logistics component is maximally technologized and automated, with transferring the main contribution to product development according to customer requirements and interaction with the consumers of the product/service in order to fully satisfy their needs and expectations.

5. Discussion

According to economic theory, economic assets are individually or collectively owned objects whose owners can derive economic benefits from owning or using them. The value of economic assets is constantly changing and depends on the size of the benefits obtained.

There are three elements of economic assets:

1. The object must be owned;
2. The owner must derive economic benefits from owning or using the object;
3. The asset can be sold to other economic agent (institutional entities, firms, household).

Considering the DO in terms of assets, we can see that the key aspect is the fact that the property is owned. There is currently a gap of knowledge on this subject. Legal regulation does not allow to unambiguously determine the owner of the DO, as well as to give its exact definition. The second criterion is almost always fulfilled. The owner always benefits from using the DO. However, sales and other deals with the DO are impossible due to the ambiguity of the concept itself. The role of the participants in creating the DO is also unclear. For example, a company that is on the verge of bankruptcy and was forced to send most of its employees on vacation ordered the development of a digital twin (DT) of the product, which surpassed its competitors by a number of parameters, and was at the limit of physical feasibility in terms of the key parameter. The company had experience with the DO and the results presented for it were convincing. Owing to the DO, the customer, the banks, the insurance companies were able to manage their risks. Due to the relatively low costs that the company incurred by placing the order with a leading engineering company, the company won the tender for manufacturing the products. This provided the company with a guaranteed demand for its products for three years. Being the largest employer in its town, the company provided jobs for about 1000 people. The important questions that need to be further addressed are following:

- How can the contribution of the DO to the company's economy can be assessed?
- Can the royalty principle be applied in this example, or is it necessary to develop new mechanisms for accounting for the contribution of participants in the new labor division system?

The study we have carried out leads us to formulate several criteria characterizing the DO. The DO provides complete information for the PO it corresponds to. The DO is predictable and based on the principle of hierarchical integrity. The DO reproduces the PO with a high degree of accuracy. The DO can be trained, combining all the data obtained during the operation of the object. Furthermore, the DO can be easily integrated into higher-level objects, thus DO becoming an asset (Table 1).

Thus, the main properties of DO are presented in the table. It can be seen that DO properties change from the stage of DO creation to the stage of its joint work DO/PO (Table 1).

Economics is often defined as the science of rational choice. The choice is always guided by certain criteria: technological, economic, environmental, social [54]. Offering long-term perspectives, the DO serves as a digital asset for the entire lifecycle of the PO. It is an asset that in itself brings tangible benefits to its owner and collaborator. At the same time, the cost of the DO (economic criterion) can be defined as the difference between the economic benefit in a situation when the DO is used and when it is not. Notably, the DO must be registered so that it can bring benefits as a company asset [55].

Overall, the paper contains a few interesting concepts, such as digital platform, DO asset, but the issue for future research is an analytical framework in which DO is integrated into real economic activities. Authors could discuss in future works the issue how to evaluate the economic benefits of DO when it is used.

Table 1. The main features of the DO.

| DO Properties | DO Creation Phase (Before PO Commissioning) | PO + DO Operation Phase |
|---|---|--|
| Information completeness | Engineering and production data, Characteristics and parameters of the created object Operating Cost Calculation | Operating Instruments: Modeling the control process (scenarios) Performance data Service (repair) data Operating cost management |
| Predictiveness | Predicting the behavior of a developed object, Functionality modeling | Production control Predicting production scenarios Repair/Operation Modeling |
| Hierarchical integrity | Drawings of the system, assemblies and elements Manufacturing instructions Operating instructions | Visualization of parameters of production processes and characteristics of an object during operation, in general, and by nodes and elements |
| Visualization | Visualization of engineering and technological solutions | AR/VR for management, operation, training, marketing |
| System of division of labor and cooperation | Participation in the development of the object of economic entities: investor/consumer/operating organization/designer/builder/manufacturer/transport and logistics companies/... | Cooperation (collaboration) of economic entities participating in the division of labor on the basis of a single digital platform |
| Integration in higher-level models | Working in a single digital platform with the ability to integrate into other digital platforms | Creation of new ecosystems and creation of new values based on the collaboration of economic agents |

6. Conclusions

The ontology of the DO concept is considered. The concept of a DO as an asset from an economic point of view has been discussed in the article. We could suggest the term digital asset as the value being added by DO to PO. Several questions outside the scope of this study can be selected as directions for further research. Special attention should be paid to substantiating the consumer value of the DO, what new “requests” to the economic model are generated by digital transformation of the economy, the economic benefit for the consumer and for the developer of the DO in monetary terms, the possible form of collaboration between the consumer and manufacturer of the DO, which costs it entails, to what extent the consumer is ready and motivated to take part in such a collaboration and, most importantly, how to assess the economic benefits of such a collaboration, in other words, how to explain to the consumer the fact that there is a decision to apply IT, make capital investments, or save some funds.

Another issue to be explored further are the existing economic models for assessing such economic benefits of collaboration between the consumer and the provider of the DO, their disadvantages in the context of the new paradigm of the digital economy.

A certain additivity of the costs of the DO exists: growth from zero (there are no DOs) to a certain level, while new terms that describe various innovations and digitalization technologies are added.

A DO can be considered from the point of view of economic theory, structuring three layers of the product:

- Product by design, the main benefit; augmented product - after-sales service;
- Ready physical product;
- and the product marketing shell.

Currently, digital transformation processes carry a number of objective economic challenges:

Personalization of the offer of goods and services. Companies seeking to increase their market share should not just expand their assortment or conduct an aggressive advertising campaign primarily follow the modern trend of customizing goods and services and provide customers with personalized offers.

The objective need is for participation in collaboration, and not in the competition for the client. At the same time, collaboration provides an opportunity for the client to participate in developing personalized products, and provides manufacturing companies with the opportunity to maximize their production capacities where possible, attracting the production capacities of partner companies to manufacture personalized products in collaboration. The economic effect can be estimated as the difference in the value added with and without collaboration. However, not all estimates can be limited to monetary terms. It is possible to use a multicriterial assessment (for example, by the method of analysis of hierarchies), rather than just cost-benefit analysis. As pointed out in literature, it is often impossible to confine the consideration to monetary equivalents; it is necessary to assess the time saved for requesting information, making strategic and operational decisions, other factors such as environmental friendliness, “sustainability”, and possibly some social aspects. Such cooperation, instead of competition, in turn, leads to two main challenges:

Collaboration with clients based on creating and improving the digital twin of the product to bring it to the maximum possible compliance with the client’s requirements, which implies the highest degree of trust between the participants in the collaboration.

Collaborations between manufacturers of goods and between service providers based on the tool that the digital platform becomes. Thus, the digital platform allows improving the quality of goods and services based on the complete exchange of information between its participants, which gives reason to consider it as a new factor of production, providing an objectively necessary new format of economic relations based on collaboration (in addition to such factors of production as land, capital, labor, and entrepreneurship, which ensure company growth in the age of competition).

A collaboration that is objectively developing in all directions leads to a new challenge of digital transformation, the material embodiment of the ever-increasing value of companies in the form of an intangible object that is the DO as a digital asset, which can be regarded as a new previously unknown driver of economic development which must be reconsidered from the standpoint of new economic approaches in the era of the new technological order that is Industry 4.0.

This raises the question about the importance of such types of markets as oligopoly and monopoly for the growth of public goods; previously, they were considered less productive in comparison with perfect competition. The fact is that when it comes to providing personalized services and goods to customers, a market with all the external features of oligopoly generates in practice a higher level of public good compared to no collaboration and perfect competition in an analogue economy. This phenomenon, which can be interpreted as “oligopolistic collaboration based on digital platforms”, requires careful study and rethinking.

Digital transformation poses the task of economic interpretation of the causal relationships between the digital platform and the digital asset, the digital twin and the digital asset, and in a broader sense, the growth in the value of digital assets based on digital platforms and digital twins ensured by an economic mutually beneficial collaboration that has become a characteristic feature of digital transformation, which makes the modern business environment fundamentally different from the analogue economy.

Author Contributions: All the authors contributed substantially to the entire work reported. They read and approved the final manuscript. V.Y. performed project administration and supervision. V.B. contributed to conceptualization and conceived the theoretical framework. E.d.I.P. contributed to both data curation and formal analysis, and N.B. contributed to the literature review; A.F. contributed to formal analysis; S.B. developed the methodology and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: The research is partially funded by the Ministry of Science and Higher Education of the Russian Federation as part of World-class Research Center program (Contract No. 075-15-2020-934 dated 17.11.2020).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflict of interest.

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